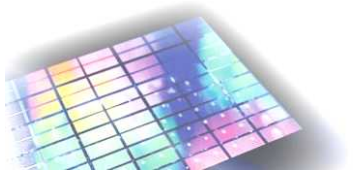
TOPPAN
Technical Research Institute

A study of cleaning characteristics for EUV mask blanks

Kyoko Sakai, Yo Sakata,
Tadashi Matsuo, Keishi Tanaka

Product Innovation Laboratory,
TOPPAN PRINTING CO., LTD.



Contents

- Introduction
- Experimental

A TD-GC/MS analysis of organic compounds on EUV blanks

- after wet cleaning
- after keeping in conventional shipping cases
- after UV/O_3 treatment

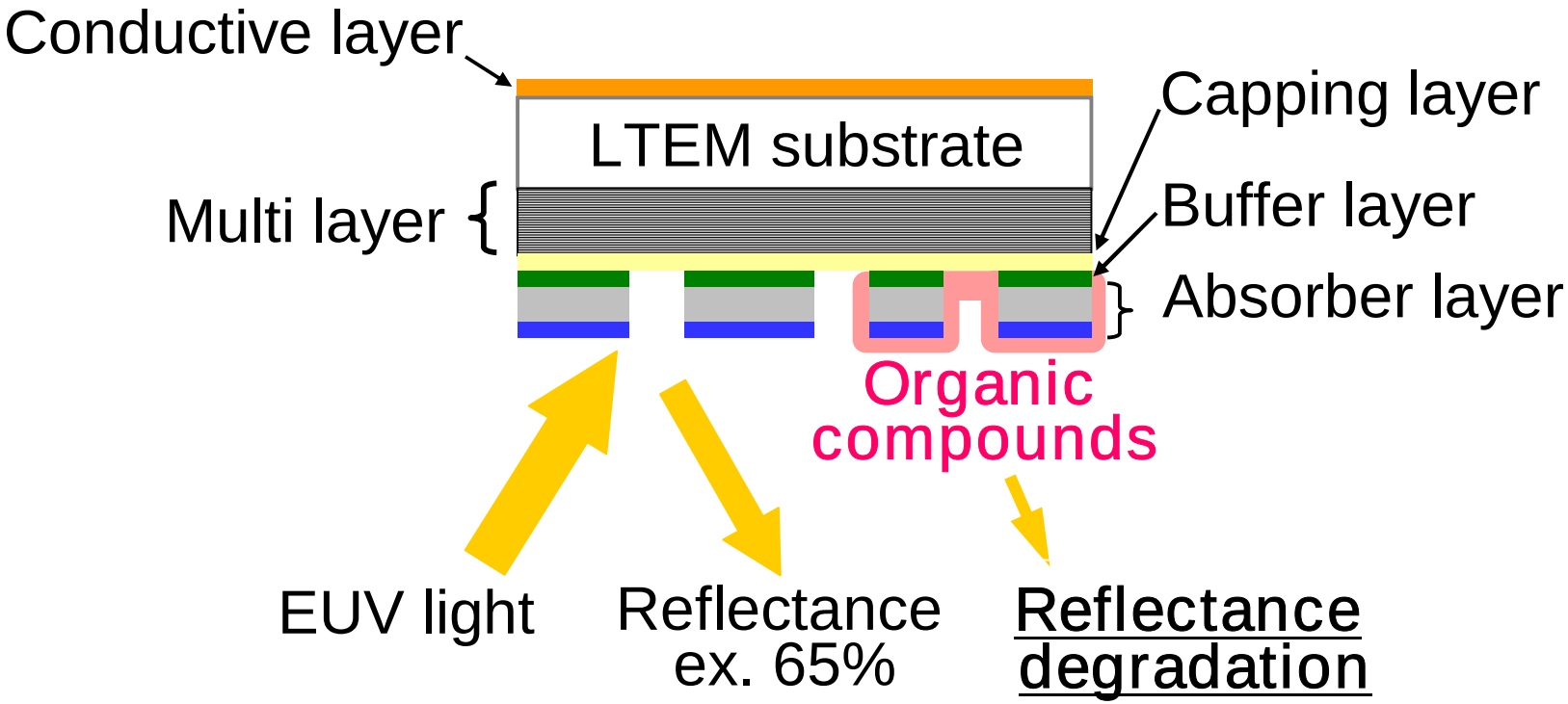
B Measurement of effects on UV/O_3 treatment for EUV blanks

- EUV reflectance
- XPS analysis
- DUV reflectance (199nm,257nm : Defects inspection wavelength)

- Summary

Introduction - Requirements for EUV mask

- **Organic contamination control**
  Organic compounds cause carbon contamination in the vacuum chamber, which degrades the reflectance of EUV mask.

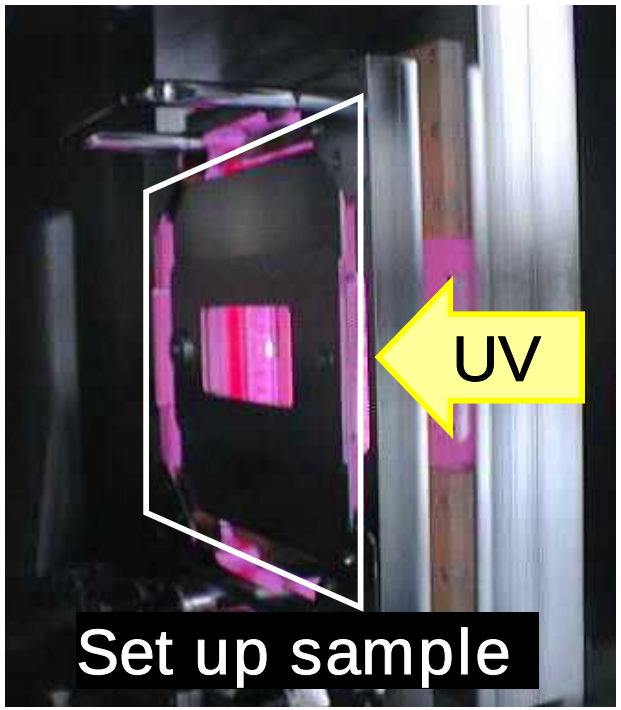


Introduction - Dry cleaning methods

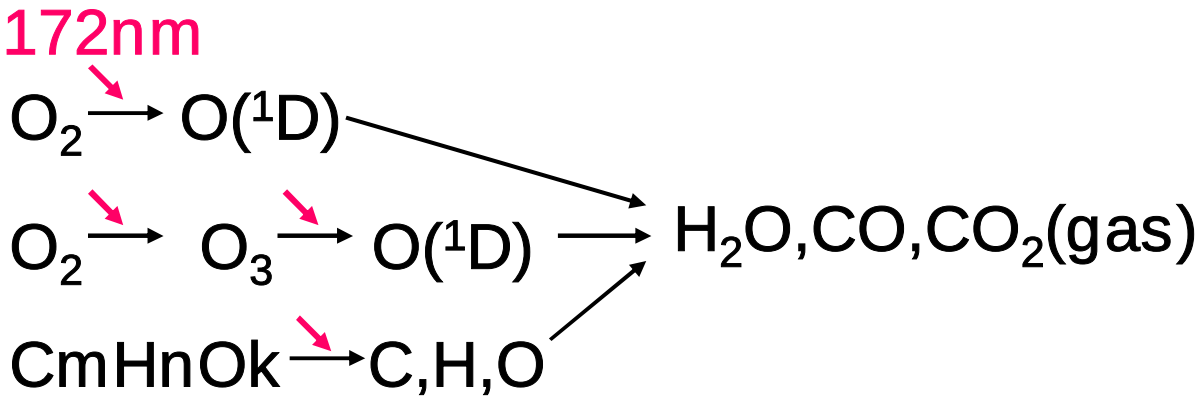
UV/O_3 treatment

Excimer lamp@172nm

$10.2mW/cm^2$

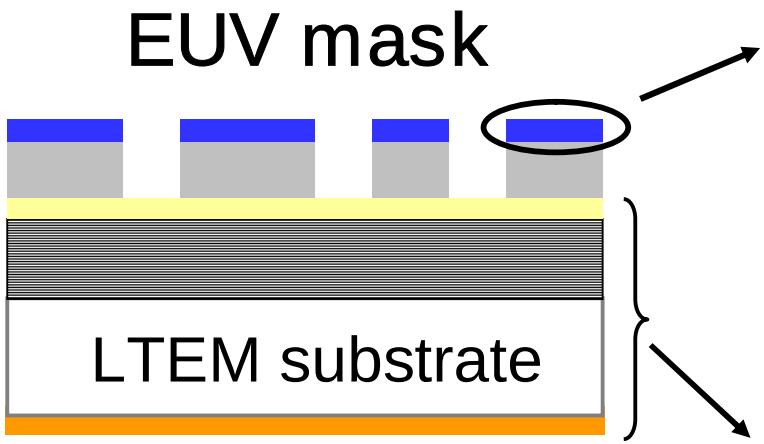


UV/O_3 treatment is one of dry cleaning methods to remove organic compounds by photo-oxidative decomposition.

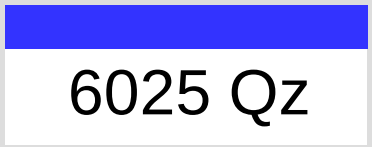


UV/O_3 treatment may also cause the reflectance degradation by oxidation of EUV mask surface.

Experimental - Sample structure

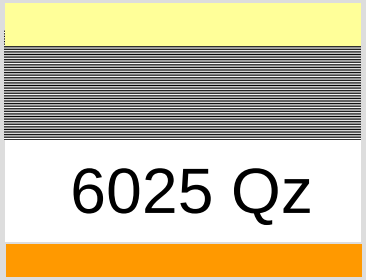


Sample name: LR-TaSi



LR-TaSi 500 Å
(Absorber)

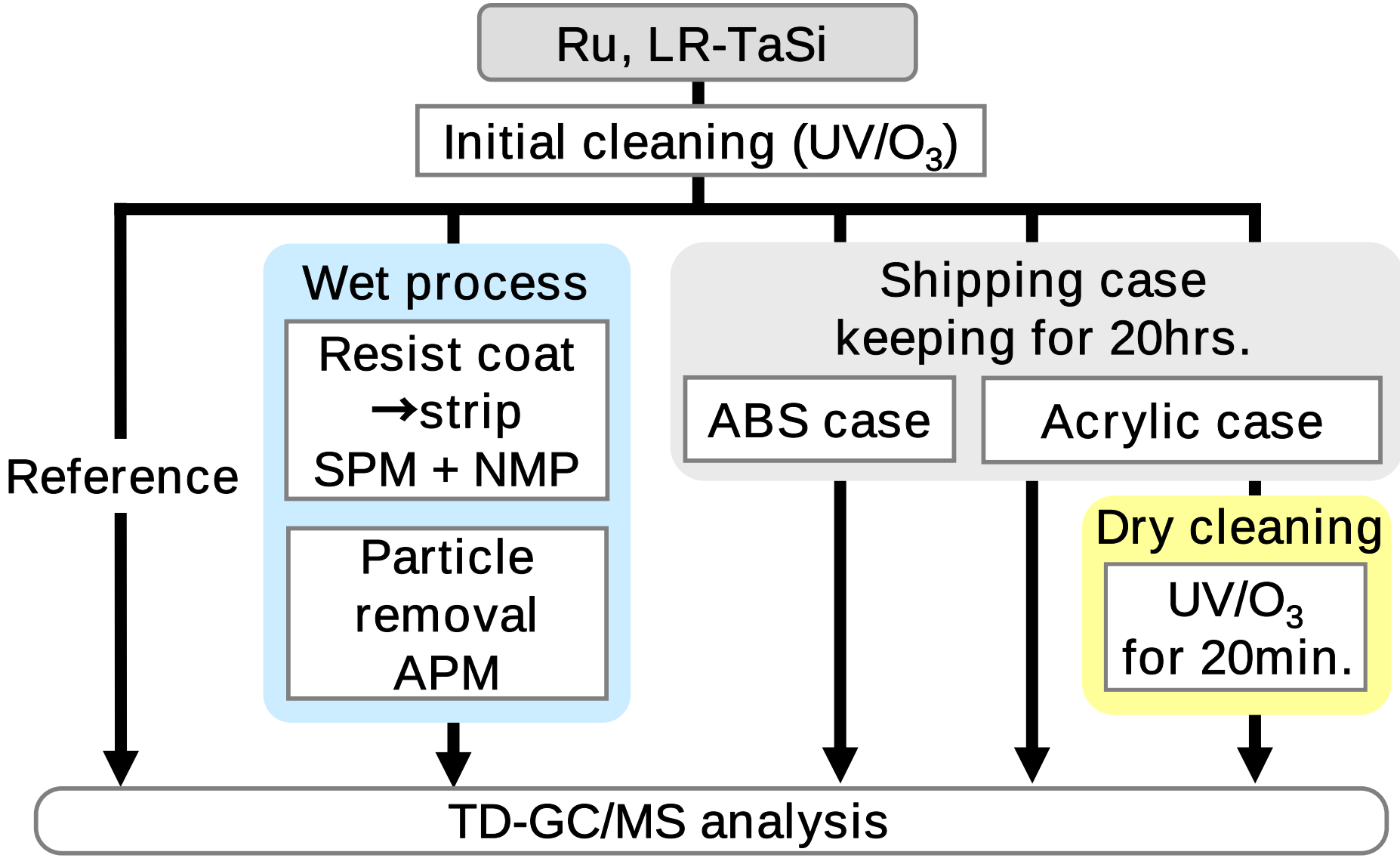
Sample name: Ru



Ru 25 Å
(Capping layer)
Multi layer

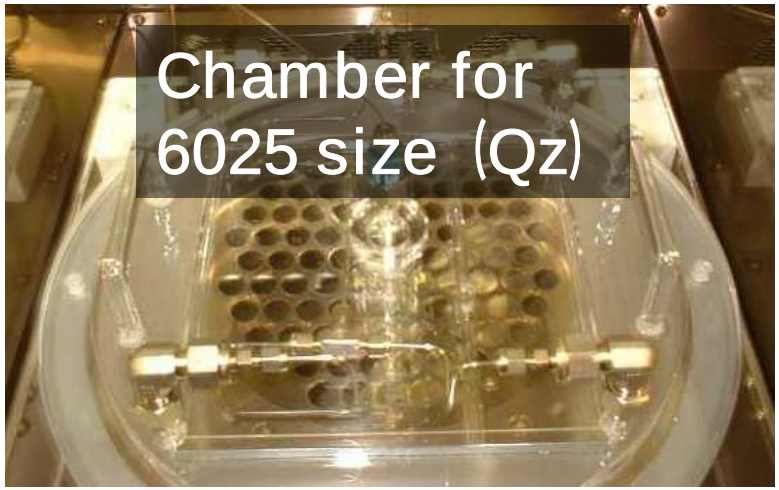
Conductive layer

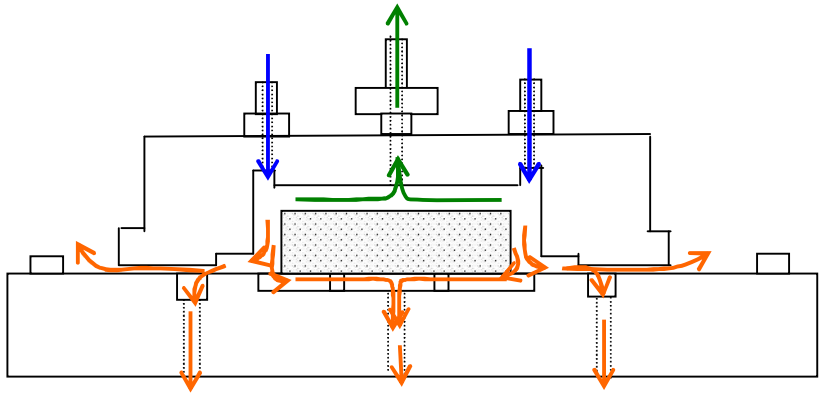
Experimental A - Procedure



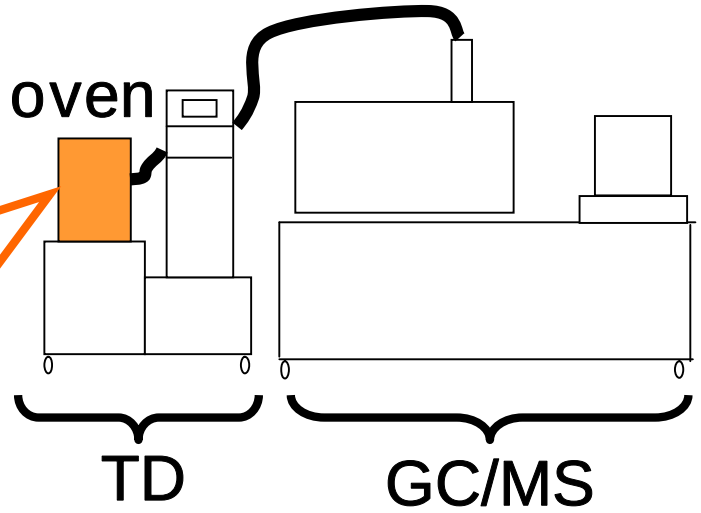
Experimental A - Organic analysis tool

TD (Thermal desorption) - GC/MS





He gas flow control



TD condition

30℃
→ 300℃ (15℃/min)
→ 300℃ (42min hold)

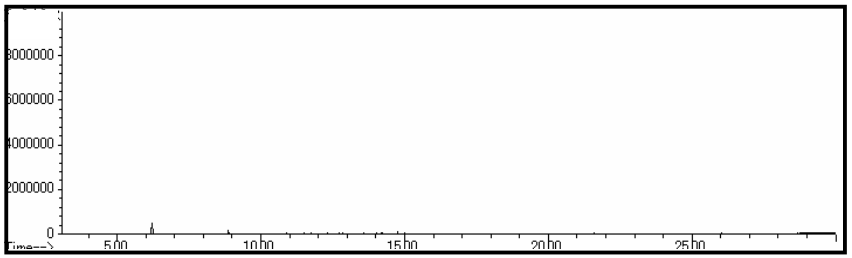
GC condition

40℃ (5min)
→ 280℃ (10℃/min)
→ 280℃ (21min hold)

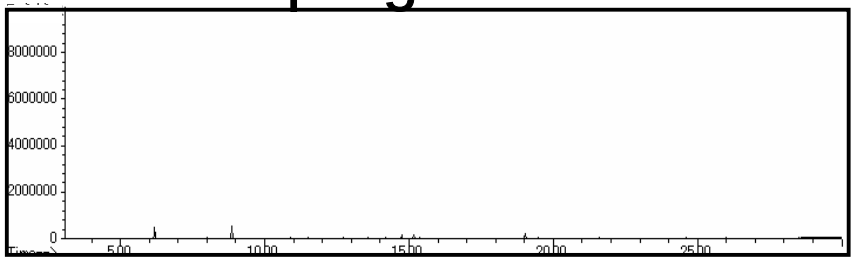
Experimental A-1 - TD-GC/MS analysis

Ru

Reference

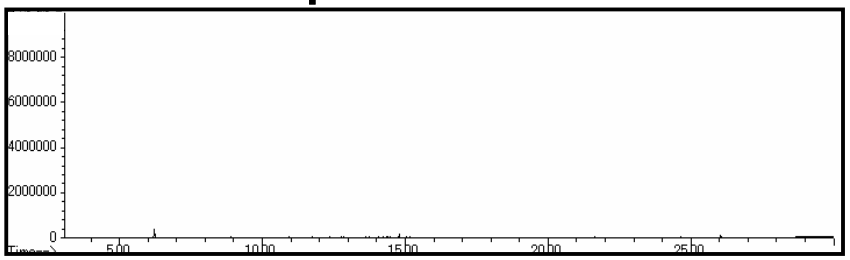


After keeping in ABS case



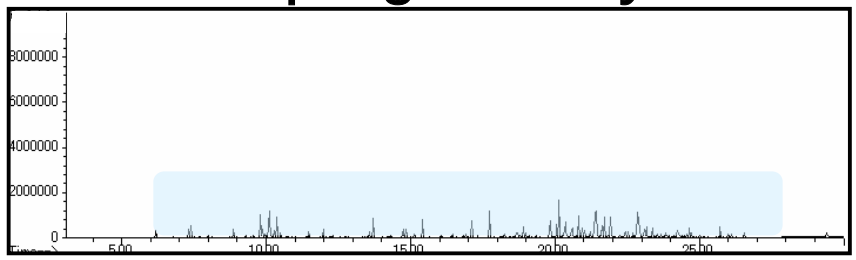
Abundance →

After wet process



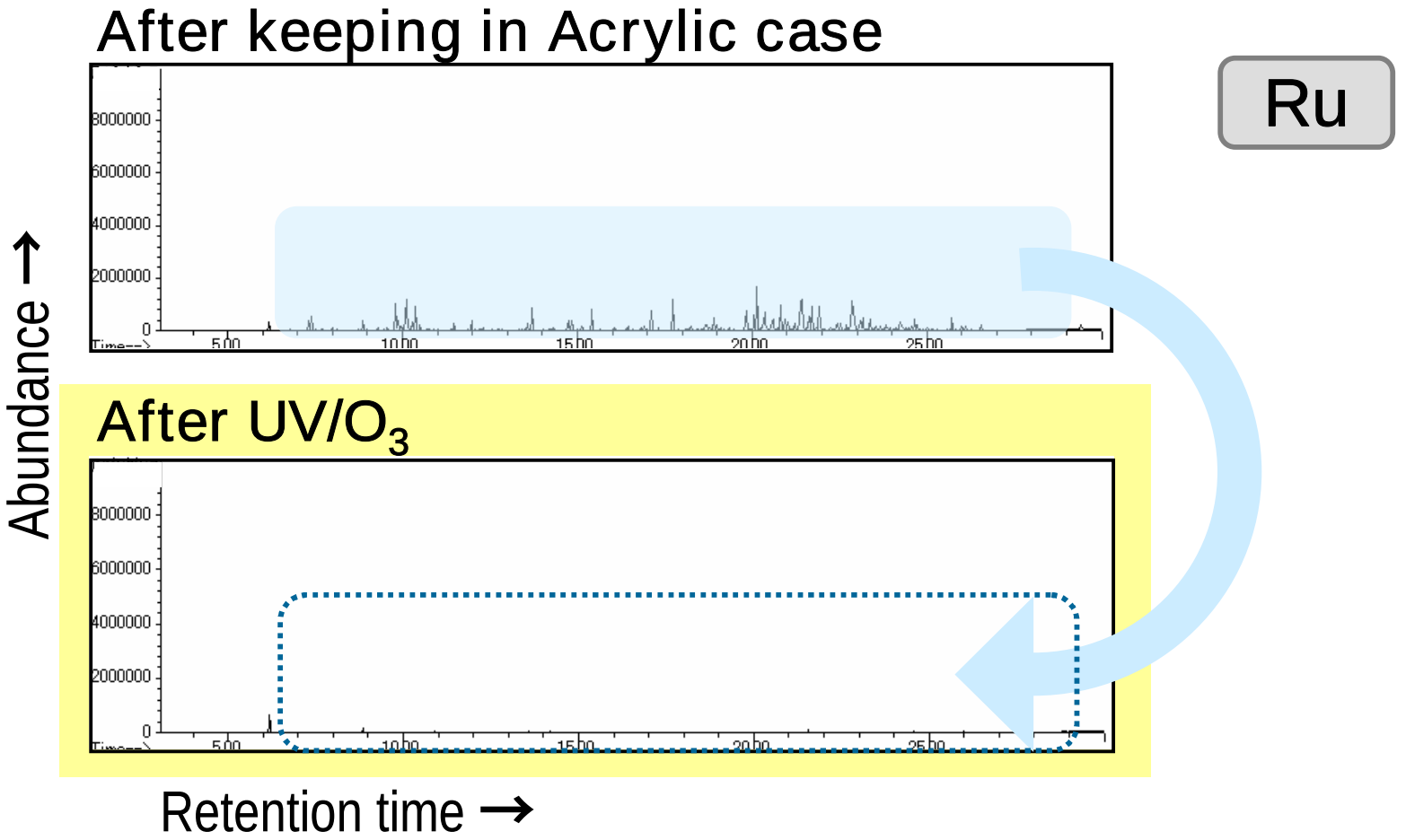
Retention time →

After keeping in Acrylic case



- straight-chain hydrocarbons
- ketone

Experimental A-2 - TD-GC/MS analysis

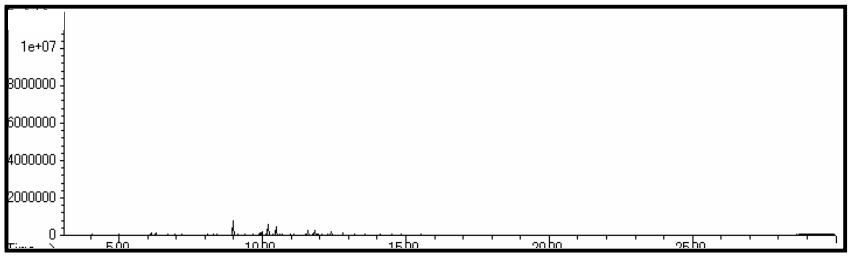


Organic compounds derived from acrylic case were successfully removed.

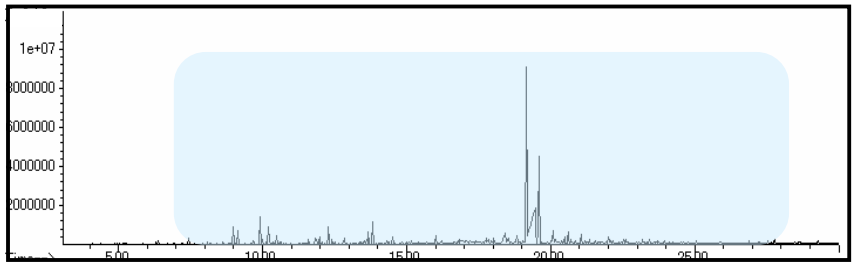
Experimental A-3 - TD-GC/MS analysis

LR-TaSi

Reference



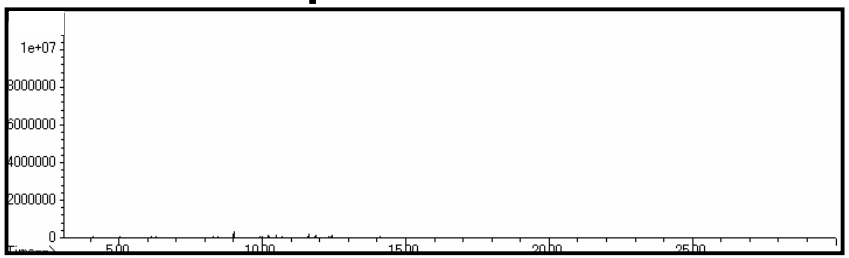
After keeping in ABS case



・aromatic hydrocarbons

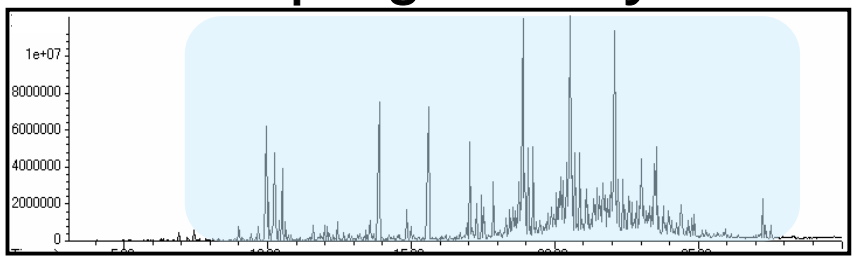
Abundance →

After wet process



Retention time →

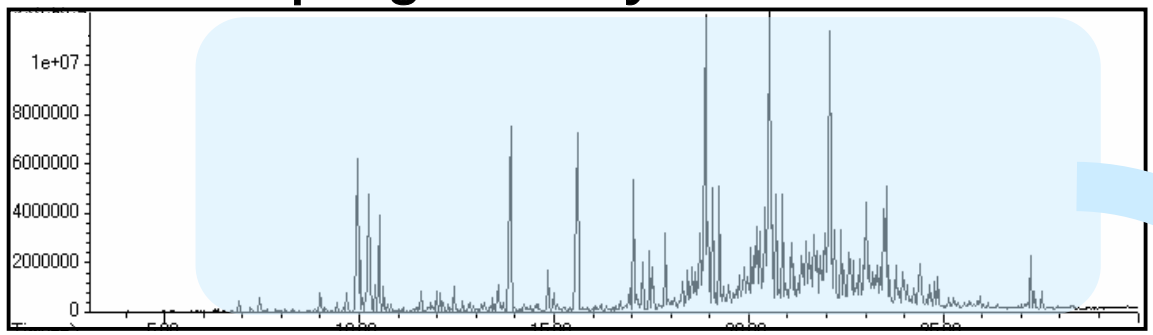
After keeping in Acrylic case



・straight-chain hydrocarbons

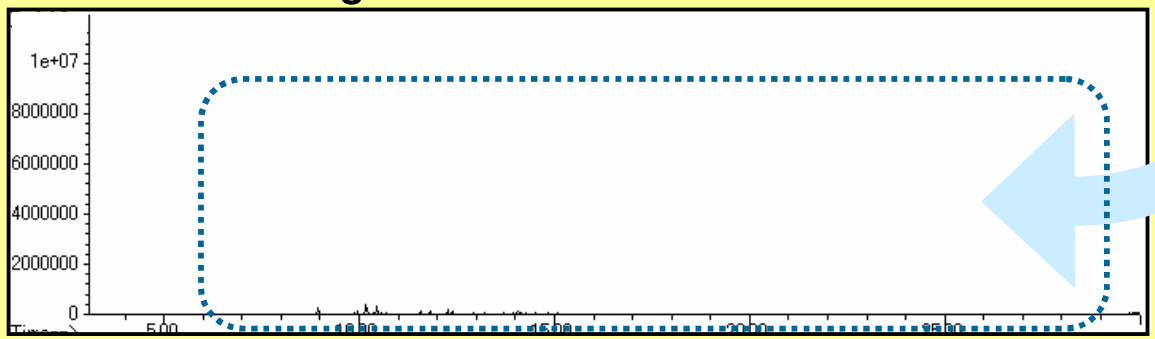
Experimental A-4 - TD-GC/MS analysis

After keeping in Acrylic case



LR-TaSi

After UV/O_3

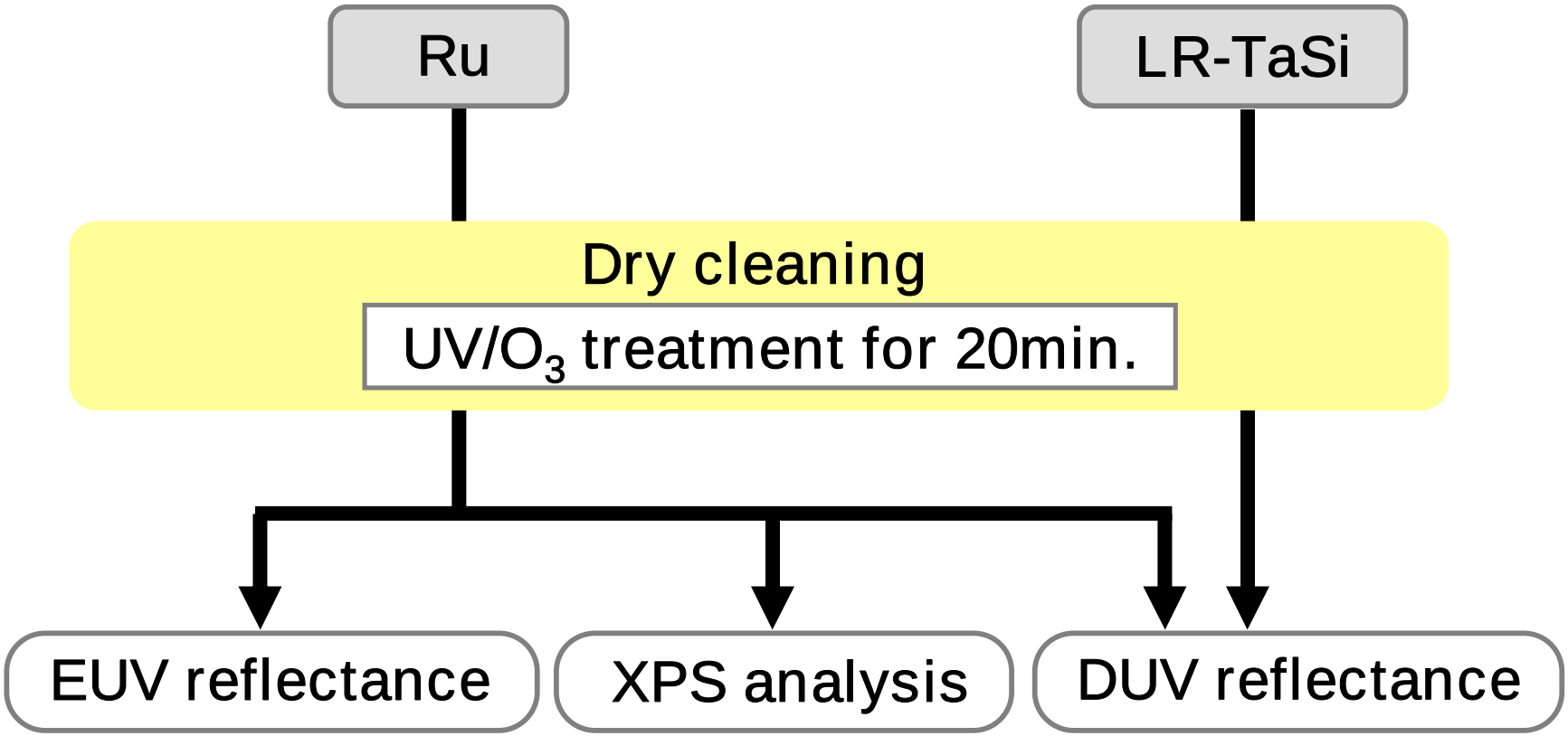


Abundance →

Retention time →

Organic compounds derived from acrylic case were successfully removed.

Experimental B - Procedure

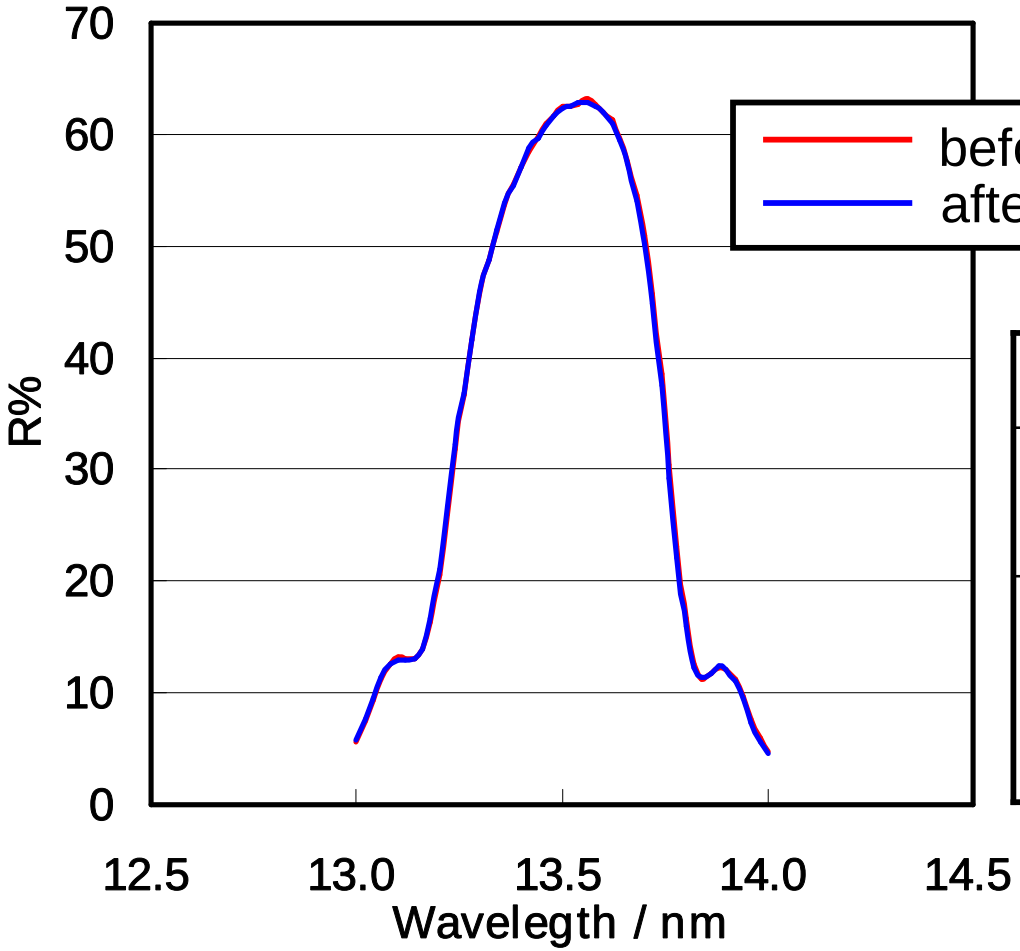


@199nm,257nm

Defects inspection wavelength

Experimental B-1 - EUV reflectance

Ru

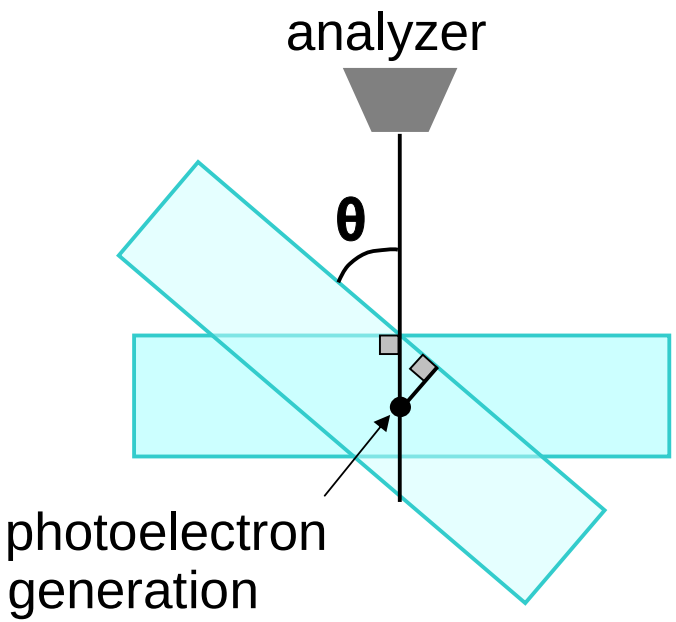


	before UV/O_3	after UV/O_3
Centroid wavelength	13.50 nm	13.50 nm
Reflectance @ Centroid wavelength	63.24%	62.84%

Both reflectance curves were almost overlapped.

Experimental B-2 - XPS analysis

Ru



45 ° deep position
25 ° shallow position

	angle θ	area ratio O1s/Ru3d$_{5/2}$
Before UV/O_3	45°	1.0
	25°	1.7
After UV/O_3	45°	1.1
	25°	1.8

Differences of area ratio between before/ after UV/O_3 were within experimental accuracy.

No significant Ru surface oxidation by UV/O_3 was confirmed.

Experimental B-3 - DUV reflectance

Ru | LR-TaSi

R% after UV/O_3 - before UV/O_3	199nm	257nm
Ru	0.16%	0.16%
LR-TaSi	0.40%	0.30%

Differences of between before/ after UV/O_3 were equivalent to experimental accuracy.

No remarkable change of reflectance between before / after UV/O_3 was confirmed.

Summary

- Few organic compounds after wet process exist on Ru capping and LR-TaSi absorber, equivalent to reference.
- A lot of organic compounds were detected on Ru capping and LR-TaSi absorber after keeping in acrylic shipping case.
- UV/O_3 cleaning was found an effective means for removing organic compounds derived from shipping case.
- EUV reflectance and surface oxidation on Ru capping didn't change significantly by UV/O_3 treatment for 20min.
- Reflectance at 199nm, 257nm on Ru capping and LR-TaSi absorber didn't change by UV/O_3 treatment for 20min.

Acknowledgement

The authors would like to thank Selete for EUV reflectance measurement.